Year 12

Chemistry

2005

Name: ....

Teacher: ....

Time allowed for this paper
Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Separate Multiple Choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate
Standard Items: Pens, pencils, eraser or correction fluid, ruler
Special Items: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council for this subject.

Important note to candidates
No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Part	Format	No. of Questions Set	Number of Questions to be Attempted	Marks available	Suggested working time (minutes)
1	Multiple choice	30	All	60 (30%)	55
2	Short answers	11	All	70 (35%)	60
3	Calculations	5	All	50 (25%)	45
4	Extended answer	1	1	20 (10%)	20

Total marks   200 (100%)

Instructions to candidates

1. The rules for the conduct of Tertiary Entrance Examinations are detailed in the booklet *TEE Handbook*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions:

    Part 1   Answer **all** questions, using a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **not** use a ball point or ink pen.

    If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers.

    Feel free to write or do working on the question paper; many students who score high marks in the Multiple Choice Section do this.

    Parts 2, 3 and 4   Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

    Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers for such questions which do not show working will not be awarded full marks.

3. The examiners recommend that you spend your reading time mainly reading the instructions to candidates and Parts 2, 3 and 4.

4. **Chemical equations**

    For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example Ag^+ (aq)], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

PART 1   (60 marks)

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided, using a 2B, B or HB pencil. Each question in this part is worth 2 marks.

1.   Element X has the outer shell electron configuration $..s^2p^3$. Element Y has the outer shell electron configuration $..s^2$. The most likely formula of the compound formed by X and Y is which of the following?

   (a) Y_3X_2

   (b) XY_2

   (c) Y_2X_3

   (d)   YX

2.   The compound between elements X and Y in Question 1 above is most likely to be which of the following?

   (a)   A covalent network compound.

   (b)   A covalent molecular compound.

   (c)   A metallic compound.

   (d)   An ionic compound.

3.   An element A belongs to Group IV of the periodic table. Which of the following lists indicates the possible number of protons, neutrons and electrons in an atom of A?

   (a)   4 protons, 4 neutrons and 4 electrons.

   (b)   12 protons, 12 neutrons and 12 electrons.

   (c)   16 protons, 16 neutrons and 16 electrons.

   (d)   32 protons, 41 neutrons and 32 electrons.

4.   Which one of the following has dipole-dipole forces and dispersion forces but not hydrogen bonding between its molecules in the solid phase?

   (a) CO_2

   (b)   HCl

   (c) C_2H_5OH

   (d) H_2O

5. Which of the following molecules contains at least a single bond, a double bond and a triple bond?

    (a) CH_2CHCCH

    (b) $CH_2Cl(CH_2)_3CH_3$

    (c) $CH_2CClCClCH_2$

    (d) $CH_3CHBrCH_3$

6. According to the Standard Reduction Table, which of the following 1.0 mol L^{-1} solutions is not stable due to a predicted spontaneous redox reaction between its ions?

    (a) $Hg_2(NO_3)_2$

    (b) $CuBr$

    (c) $MgSO_4$

    (d) FeI_3

7. A 1.00 mol L^{-1} solution of chromium(III) chloride (a neutral solution) is electrolysed using inert electrodes. According to the Standard Reduction Table, which of the following gives the correct anode and cathode products respectively?

    (a) Chromium metal and oxygen gas.

    (b) Oxygen gas and hydrogen gas.

    (c) Oxygen gas and chromium metal.

    (d) Hydrogen gas and chlorine gas.

8. A blood alcohol test found that a driver's blood contained 23 millimoles of alcohol (ethanol) per 100 mL of blood. Which of the following is the correct value of the concentration of the ethanol in the driver's blood in mol L^{-1}?

    (a) 0.023 mol L^{-1}

    (b) 0.23 mol L^{-1}

    (c) 1.4 mol L^{-1}

    (d) 3.7 mol L^{-1}

9. Which of the following molecules is polar i.e. it possesses an overall molecular dipole?

    (a) CCl_4

    (b) CH_4

    (c) $CHCl_3$

    (d) C_2H_2

10. A chemist added 20.0 mL of 0.0010 mol L^{-1} hydrochloric acid to 100.0 mL of 0.100 mol L^{-1} potassium chloride solution. Which one of the following is the correct pH of the resulting solution?

    (a) 2.6
    (b) 3.0
    (c) 3.8
    (d) 5.2

11. Which of the following correctly describes a phosphate ion?

	Number of bond pairs of electrons	Number of lone pairs of electrons	Charge on ion
(a)	3	8	-2
(b)	4	12	-3
(c)	4	8	-4
(d)	3	9	-2

12. Equal volumes of 0.1 mol L^{-1} solutions of ethanoic acid and sodium ethanoate are mixed. Which of the following statements about the resulting solution is true?

    (a) The concentration of both hydrogen ions and ethanoate ions is high.

    (b) The concentration of both hydrogen ions and ethanoate ions is low.

    (c) The concentration of hydrogen ions is higher than the concentration of ethanoate ions.

    (d) The concentration of hydrogen ions is lower than the concentration of ethanoate ions.

13. When 1.0 mol L^{-1} solutions of the following are mixed, which combinations will result in the formation of precipitates?

    (1) $Ba(NO_3)_2$ and HCl

    (2) $Ca(NO_3)_2$ and Na_2CO_3

    (3) $Cu(NO_3)_2$ and KOH

    (4) $Zn(NO_3)_2$ and **limited** $NH_3(aq)$

(a)   1, 2 and 3 only

(b)   2 and 3 only

(c)   2, 3 and 4 only

(d)   1, 2, 3 and 4

14. One mole of each of the substances listed below is dissolved separately in water to make one litre of solution. Which solution has the highest total concentration of ions?

(a)   Ammonia.

(b)   Ammonium sulfate.

(c)   Copper(II) sulfate-5-water.

(d)   Sugar $(C_{12}H_{22}O_{11})$.

15. Pure carbon in the form of diamond has a higher melting point than tungsten, a transition metal. Which of the following best explains this difference?

(a)   Diamonds are denser than tungsten so the dispersion forces between the carbon atoms are stronger.

(b)   Tungsten has fewer electrons in its outer shell than diamonds, so the dispersion force between its molecules is less.

(c)   The extended covalent bonding in diamond is stronger than the metallic bonding in tungsten.

(d)   The molecules in diamond are polar, and the dipole-dipole attraction in diamond is stronger than the metallic bonding in tungsten.

16. A 62 g sample of a molecular compound contains 20 g of oxygen and equal masses of carbon and nitrogen, combined together. Which of the following is nearest to the empirical formula of the compound?

(a) $C_7O_5N_6$

(b) $C_6O_8N_7$

(c) C_2O_4N

(d) $C_6O_4N_7$

17. Which of the following statements best describes 10 mol L^{-1} ammonia solution?

(a) A concentrated solution of a weak base.

(b) A dilute solution of a strong base.

(c) A concentrated solution of a strong base.

(d) A dilute solution of a strong electrolyte.

18. Which of the following reactions represent disproportionation (self oxidation - reduction)?

I $2CrO_4^{2-}(aq) + H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + OH^-(aq)$

II $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

III $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

IV $2Cu^+(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$

(a) I only

(b) II and IV only

(c) III only

(d) IV only

19. Which of the following examples represents an acid-base reaction?

(a) $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(aq) + H_2O(l)$

(b) $2NO_3^-(aq) + 2H^+(aq) + 3H_2O_2(aq) \rightarrow 2NO(g) + 3O_2(g) + 4H_2O(l)$

(c) $2K(s) + 2H_2O(l) \rightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$

(d) $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

20. In which of the following pairs of species is the oxidation number of chlorine different?

  (a)   NaCl, $ZnCl_2$

  (b) Cl_2O, ClO^-

  (c) $NaClO_3$, ClO_3^-

  (d) $Zn(ClO_3)_2$, $Al(ClO_2)_3$

21. For the titration between dilute ethanoic acid (in a burette) and standardised sodium hydroxide
     in a conical flask, which of the following procedures is incorrect?

  (a)   Prior to adding the acid to the burette, rinse the burette with distilled water and then a
        small portion of the acid solution.

  (b)   Pipette out 20.00 mL aliquots of the sodium hydroxide solution into three separate
        conical flasks which have each been rinsed with the sodium hydroxide solution.

  (c)   Rinse the pipette with the standardised sodium hydroxide solution before transferring
        the first aliquot to the conical flask.

  (d)   Add a few drops of phenolphthalein to each of the conical flasks containing the sodium
        hydroxide aliquots.

22. A sealed glass tube at room temperature contains nitrogen dioxide (a brown gas) and
     dinitrogen tetroxide (a colourless gas) in equilibrium as given by the following equation:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \ + \ heat$$

     If the appearance of the gas mixture at room temperature is pale brown, which of the
     following indicates the changes which would be observed in the tube if it was placed in hot
     water?

  (a)   The gas mixture would gradually become darker and darker brown over a few minutes in
        the hot water.

  (b)   The gas mixture would become darker at first, but it would then become almost as pale
        brown as its original appearance while it remained in the hot water.

  (c)   The gas mixture would not undergo any noticeable change in appearance because the
        volume of the glass tube does not noticeably change while it remains in the hot water.

  (d)   The gas mixture would become even paler at first, but would then return to its original
        appearance of pale brown.

Questions 23 and 24 refer to the **simplified** energy profile diagram for photosynthesis in which carbon dioxide and water vapour combine to produce glucose and oxygen gas.

Reaction coordinate
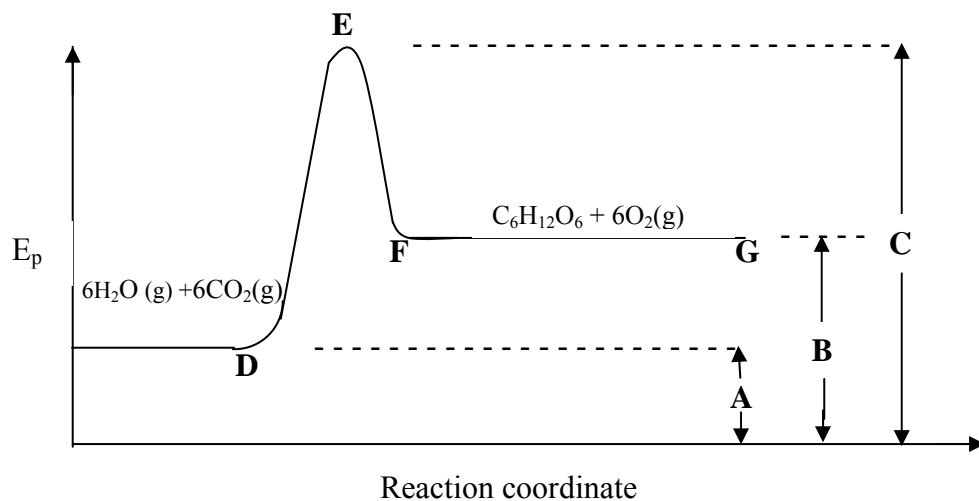
23.   From the above graph, which of the following statements is true?

(a)   The activation energy for the forward reaction is given by $(C - B)$.

(b)   The forward reaction has a heat of reaction given by $(C - A)$.

(c)   The reverse reaction is exothermic and its heat of reaction is given by $(A - B)$.

(d)   The reverse reaction has an activation energy barrier given by $(B - A)$.

24.   The activated complex for the forward reaction is indicated by which of the following positions on the graph?

(a)   **D**

(b)   **E**

(c)   **F**

(d)   **G**

25.   2-pentanone can be prepared from which of the following lists of substances?

(a)   2-pentanoic acid and 2-pentanol.

(b)   2-pentanol and acidified potassium permanganate solution.

(c)   Pentanal and acidified potassium permanganate solution.

(d)   2-pentene and pentanoic acid.

26.   Which of the following substances will react with $CH_3(CH_2)_2COOH$ to produce $CH_3(CH_2)_2COOCH_2CH_3$ and water?

(a) $CH_3CH_2CH_3$

(b) CH_3CHCH_2

(c)   Acidified potassium permanganate solution

(d) CH_3CH_2OH

27.   Which one of the following names is incorrect?

(a)   1,2,3-trimethylcyclohexane.

(b)   2,3,3-trichlorohexane.

(c)   2,3,4-trichlorocyclohexene.

(d)   4,4,5-trimethylhexane.

28.   What is the systematic name for the compound $CH_2OHCHOHCH_2OH$?

(a)   Trihydroxypropanol.

(b)   1,2,3-propanetriol.

(c)   1,2,3-trihydroxypropane.

(d)   1,2-hydroxypropanol.

29.   Which of the following compounds has only **one** distinct form of the molecule which can be drawn?

(a)   3-chloropropene.

(b)   Dichloropropanone.

(c)   Butene

(d)   1,2-dichloropropene.

30. The repeating section of an acid-alcohol condensation polymer molecule is shown below:

$$-OCCHClCH_2COO(CH_2)_2O-$$

Which of the following correctly names the acid monomer which reacted to form the polymer?

(a)   2-chloro-1,4-butanedioic acid

(b)   1,3-propanedioic acid

(c)   2-chloropropanoic acid

(d)   1,4-butanedioic acid

END OF PART 1

PART 2   (70 marks)

Answer **ALL** questions in Part 2 in the spaces provided below.

1.   Give fully balanced equations for the reactions which occur (if at all) in the following
      experiments.
      Use **ionic equations** where appropriate. In each case describe observations such as colour
      changes, precipitate formation (give the colour), or gas evolution (give the colour or describe
      as colourless) resulting from the chemical reaction.

(a)   Propanal is shaken vigorously with a solution of bromine water.

      Oxidation : ....

      Reduction : ....

      Equation : ....

      Observation : ....

      ....

                                                                                                                                [4 marks]

(b)   Concentrated ammonia solution is added to solid zinc hydroxide.

      Equation : ....

      Observation : ....

      ....

                                                                                                                                [3 marks]

(c)   Copper metal is placed in a solution of lead nitrate.

      Equation : ....

      Observation : ....

      ....

                                                                                                                                [3 marks]

(d)   A solution of ammonium nitrate is added to a solution of potassium hydroxide.

      Equation : ....

      Observation : ....

      ....

                                                                                                                                [3 marks]

2.   For each of the following descriptions, give the **name** of a suitable example.

Description of substance	Example
A colourless liquid which turns pink if added to a solution of pH greater than 8.	
A pale greenish-yellow gas which dissolves in water to produce an acidic solution.	
An orange solution which turns yellow when sodium hydroxide solution is added.	
A white substance which is insoluble in water, but which dissolves in hydrochloric acid producing a colourless, odourless gas.	

[4 marks]

3(a) A student has been asked to prepare a sample of propyl ethanoate. **Name** three substances necessary for the laboratory preparation of the above compound.

....

....[3 marks]

3(b) Draw the structure of propyl ethanoate:

[2 mark]

3(c) Name two isomers of the above substance.

....and.. [2 marks]

4.   Write an equation for the reaction which occurs at the cathode of a fuel cell which has either an acidic or basic electrolyte.

Equation : ....

[2 marks]

5.   Two half-cells are set up according to the diagram below. The reduction reaction in the palladium half cell is $Pd^{2+}(aq) + 2e^- \rightarrow Pd(s)$ and has an E^o of $+0.92$ V.
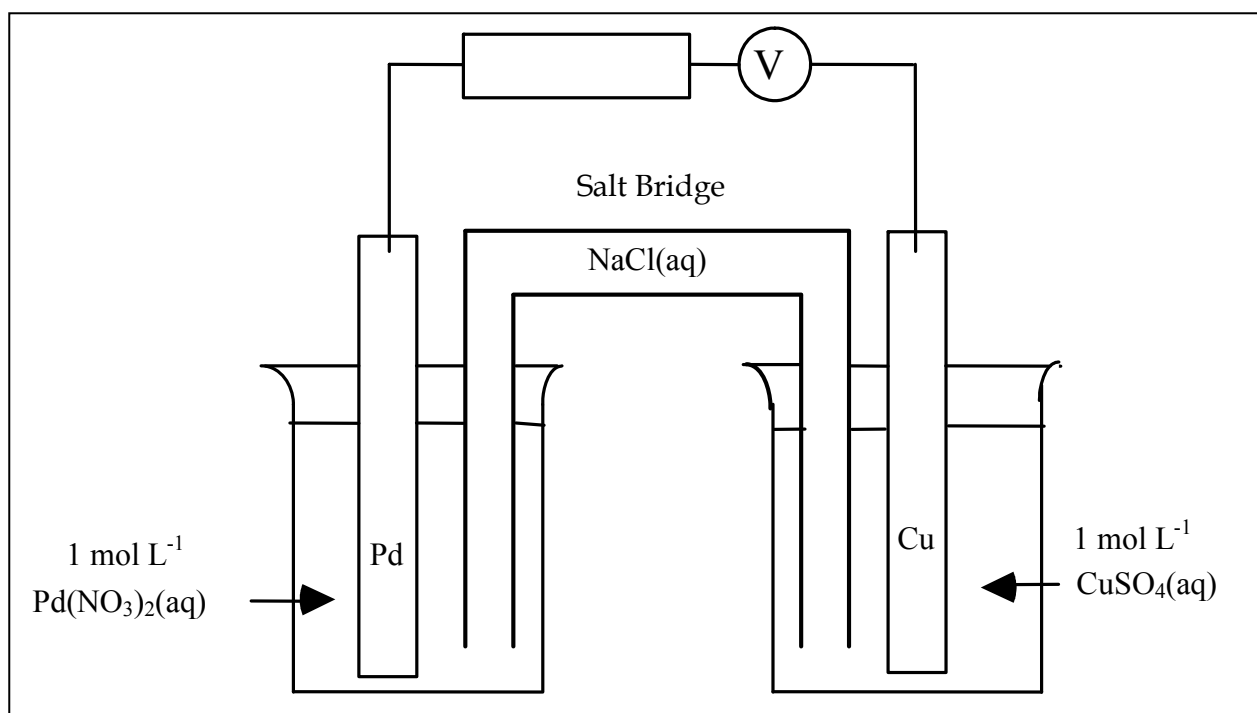
(a)   Name the oxidising agent in the redox reaction which occurs in the cell.

      ....   [1 mark]

(b)   Draw an arrow **in the box** provided on the diagram to indicate the flow of electrons in the external circuit.   [1 mark]

(c)   Give the formula of one ion that will move from the Pd/Pd^{2+} half cell towards the Cu/Cu^{2+} half cell through the salt bridge.

      ....   [2 mark]

(d)   Write a balanced equation for the anode and cathode reactions

      Anode: ....

      Cathode: ....
                                                                                                        [4 marks]

(e)   Under standard conditions, what is the maximum expected reading on the voltmeter in the external circuit?

      Answer: ....volts   [2 marks]

6.   For the species below, draw the structural formula, representing all valence shell electron pairs

either as $:$ or $\underline{}$ [For example, water $H : \overset{..}{\underset{..}{O}} : H$ or $H\!\!-\!\!\overset{-}{\underset{-}{O}}\!\!-\!\! H$ and so on]

propyne   a hydrogensulfite ion HSO_3^-

[6 marks]

7.   Explain clearly the difference between the terms "ionisation energy" and "electronegativity".
      Explain why argon has an ionisation energy but no electronegativity.
      State the trend in first ionisation energy (E_1) for the elements of Group VII of the periodic
      table.

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....[6 marks]

8. Explain why iodine, $I_2(s)$, is more soluble in kerosene (approximate formula $C_{12}H_{26}$) than it is in water. You should name all the molecular interactions, and compare their relative strengths.

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....[6 marks]

9. In an acid-base titration, 1.0 mol L^{-1} HCl(aq) (from a burette) is added slowly to 20.0 mL of 1.0 mol L^{-1} NaOH(aq) in a conical flask.
    (a) Calculate the pH of the solution in the conical flask after 19.90 mL of the HCl(aq) has been added.
    (b) Calculate the pH of the solution in the conical flask after 20.10 mL of the HCl(aq) has been added.
    (c) Comment on the change in pH

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....[6 marks]

10. In the spaces below, draw a secondary alcohol and a tertiary alcohol which each has five carbon atoms in its molecule. Give the correct systematic name for each alcohol.

Name:	Name: ....

    Secondary alcohol   Tertiary alcohol   [6 marks]

11. Give full details of one **chemical** test which would enable you to distinguish the above two alcohols.

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                                             .   [4 marks]

END OF PART 2

PART 3   (50 marks)

Answer **ALL** questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't you will lose marks.

1. The percentage purity of a sample of manganese (IV) oxide, MnO_2, can be found by treatment with an excess of a standard sodium oxalate solution in the presence of dilute sulfuric acid. The Mn^{4+} ions are reduced to Mn^{2+} in this reaction. After the reaction is complete, the excess sodium oxalate is titrated with a standardised potassium permanganate solution. One such impure sample of manganese(IV) oxide of mass 0.3350 g was reacted with 50.0 mL of acidified 0.0965 mol L^{-1} sodium oxalate. The mixture was boiled gently to dissolve the solid. After cooling, the solution was titrated with 0.0332 mol L^{-1} potassium permanganate solution. The volume of the potassium permanganate solution required was 12.5 mL. Calculate the percentage purity of the manganese (IV) oxide sample.   [10 marks]

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2.   A chlorofluorocarbon (a compound containing only chlorine, fluorine and carbon) is analysed
      by preparing two identical samples of the compound of mass 2.320 g. The first sample is
      burnt in excess oxygen gas to convert all the carbon it contains into carbon dioxide. The

second sample of the compound is chemically treated to convert all the chlorine it contains into hydrochloric acid.

a) Given that the mass of carbon dioxide produced is 0.9267 g and the hydrochloric acid produced requires 17.2 mL of a 3.062 mol L^{-1} ammonia solution for complete neutralisation, calculate the empirical formula of the chlorofluorocarbon.

[5 marks]

b) When a 1.503 g sample of the compound is vaporised in the absence of air, the vapour occupies 152.8 mL at S.T.P. From this data, calculate the molecular formula of the compound.

[3 marks]

c) Draw a full structural formula for the possible isomer(s) of the chlorofluorocarbon.

[2 marks]

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3.   In the production of sulfuric acid (H_2SO_4) from iron pyrites (FeS_2) the following unbalanced
      equations occur: $FeS_2(s) + O_2(g) \rightarrow Fe_2O_3(s) + SO_2(g)$
                            $SO_2(g) + O_2(g) \rightarrow SO_3(g)$
                            $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$

      Balance each of the above equations and combine them into one overall equation which clearly
      indicates the mole ratio between the iron pyrites and the sulfuric acid.
      Hence determine the mass of iron pyrites needed to produce 1.00 tonne of pure sulfuric acid by
      the above sequence of reactions. [Note: 1.00 tonne = 1.00 x 10^6 g]

                                                                                      [10 marks]

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4.   0.3753 g of hydrogen sulfide gas is bubbled into 150.0 mL of 0.2060 mol L^{-1} lead (II) nitrate
      solution, and a precipitate of highly insoluble lead(II) sulfide is formed.

      Determine a)   the limiting reagent   [3 marks]
               b)   the mass of precipitate formed   [3 marks]
               c)   the concentrations of all ions remaining in the final solution
                     (Assume the final volume of solution is 150.0 mL)   [4 marks]

5. In an aluminium smelter, purified aluminium oxide (alumina) is mixed with cryolite and is electrolysed at a temperature of 950^oC in a Hall-Heroult electrolytic cell. Given that a current of 300 000 A flows continuously 24 hours per day through each of 408 such cells, answer the following questions.

    a) Calculate the number of complete 22.5 kg ingots of pure aluminium which the smelter is able to produce per day.   [6 marks]

    b) Determine the total volume of carbon dioxide gas at 20.0^o C and 101.3 kPa which is produced at the anodes of the 408 cells per day.   [4 marks]

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PART 4   (20 marks)

Answer the following extended answer question.
Marks are awarded for the relevant chemical content of your answer, and also for coherence and clarity of expression. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing.

Your answer should be presented in about 1.5 to 2 pages. Commence your answer on page 28.

1.   Human blood uses effective chemical reactions which enable it to resist changes in pH above or below its normal value of 7.4.   If 10 mL of 1.00 mol L^{-1} HCl(aq) is added to 1.00 L of blood, the pH drops by only 0.2 units. This happens mainly due to equilibrium reactions involving carbonic acid (a weak acid) and hydrogencarbonate ion.

The three related equilibrium reactions which help to regulate blood pH are as follows:

(i) Gaseous carbon dioxide in the lungs is in equilibrium with dissolved carbon dioxide in the blood:
$$CO_2(g) \rightleftharpoons CO_2(aq) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation (1)}$$

(ii) The dissolved carbon dioxide reacts with water in the blood forming carbonic acid:
$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \ldots\ldots\ldots\ldots\ldots\text{Equation (2)}$$
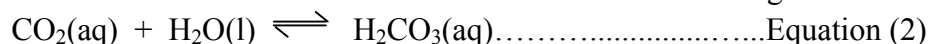
(iii) The weak acid carbonic acid is also in equilibrium with hydrogencarbonate ion and hydronium ion:
$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq) \ldots\ldots\text{Equation (3)}$$
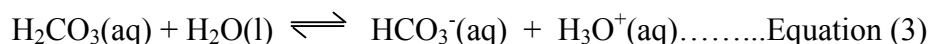
Using the above reactions, and your knowledge of Le Chatelier's Principle and/or acid-base theory:

(a)   Explain how an increase in $[H_3O^+(aq)]$ affects all three reactions.   (6)

(b)   Discuss the **position** of equilibrium in Equation (3).   (4)

(c)   Explain how hydrogencarbonate ion helps the pH of the blood to remain at 7.4.   (4)

(d)   **Compare** the effect of adding 10 mL of 1.00 mol L^{-1} HCl(aq) to a litre of blood (assume pH = 7) with the effect of adding the same amount of the acid to a litre of pure water (pH = 7).   (6)

Commence your answer on page 29

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